HYDRO-ELECTRIC INQUIRY COMMISSION

ECONOMICS

NIPIGON SYSTEM

STUDY BY WALTER J. FRANCIS

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The present study of the Engineering Economics of the Nipigon System is made following the instructions of the Hydro-Electric Inquiry Commission. In commencing the study I was assisted by Mr. R. A. Ross and Mr. M. J. Haney, members of the Commission, and by Mr. J. H. W. Bower, the Secretary of the Commission.

While the problem cannot be solved precisely without the expenditure of an immense amount of time, nevertheless I believe that the results obtained are close enough for all practical purposes and that they show clearly not only the present conditions of the economics, but also the conditions which will result in the future, according to the manner in which the variable factors may be dealt with in one of the many different ways possible.

Briefly and in the most general terms, the study shows that if the plant be developed so as to supply the demand of a market for 70,000 horse power by a definite plan of evolution by the year 1929 at a capital expenditure of $13,000,000 and if $20.00 per horse power per annum be charged for power for municipal purposes and $18.00 for pulp mill use, the accumulated deficit will disappear in the year 1929. Under the same development conditions the accumulated deficit will disappear in the year 1927 if the interest rate be taken at 5% per annum, and there

be no charge for water rental. Similarly, with a maximum interest charge of 6.2% per annum and with a water rental of $1.00 per horse power per annum on power generated, the accumulated deficit will be ever increasing, when power for municipal purposes is sold at a rate varying between $20.00 and $18.00 per horse power per annum. And, if the interest be fixed at 5% per annum and the water rental be placed at $0.50 per horse power per annum on power generated, the accumulated deficit will disappear in 1928. In a corresponding way, other results may be deduced from the diagrams according to the conditions selected.

General.

I have received the assistance of all the members of my staff as far as necessary, and particularly the aid of Mr. D. S. Ellis, M.A., formerly Professor of Mathematics at Queen's University.

The whole of the study has been based upon the information contained in the volume already submitted to the Hydro-Electric Inquiry Commission under the title,-"Economics, Nipigon System, Estimates of Hydro-Electric Power Commission". The above mentioned document consists essentially of the data supplied by Mr. F. A. Gaby, Chief Engineer of the Hydro-Electric Power Commission, in answering our requests. His reply to a preliminary general inquiry was subsequently amplified, and is contained in the above mentioned document. The references in the following explanation refer to the pages thereof.

The financial statement of the system for the year ending October 31st, 1921, as given by Mr. G. T. Clarkson, shows the capital expenditure to be $6,347,705.45 if the rate of 5% per annum be taken for the interest charge during construction, or $6,387,913.22 if 6.2% be taken, the difference due to the interest rate being $40,207.77.

In Mr. Clarkson's figures given above an amount of $115,452.67, being that invested for lines and station in the original system, is not included by us, since it is really apart from the "Nipigon System" under consideration. Mr. Gaby explains his view on page 22 of the above mentioned document, as follows:-

> "The capital covered by the lines and station originally used to receive and distribute power purchased from the Kaministiquia Power Company have not been considered in the capital shown in the report, as negotiations have been going on for some time between the Public Utilities Commission of Port Arthur and the Hydro Commission covering the sale of these properties, and this report deals entirely with 'Nipigon Development Capital'."

If the amount be considered as part of the capital expenditure, the earlier items of capital expenditure will be increased correspondingly, but the general results obtained in our study will not be materially altered in principle or in fact.

The total deficit of the system for the year ending October 31st, 1921, has been taken at $64,849.00, the interest being computed at 6.2% per annum, and the water rental at $1.00 per horse power per annum for power sold; and at $21,710.00, the interest being computed at 5% per annum, and the water rental at $0.50 per horse power per annum for power generated.

Diagrams.

The results of the studies of Mr. Gaby's estimates have been shown on the eight drawings forming pages 13 to 20 hereof, as follows:-

Page	Sheet	Title
13	1	Power Diagram,
14	2	Annual Revenue Diagram,
15	3	Profit and Loss Diagram,
16	4	Profit and Loss Diagram,
17	5	Profit and Loss Diagram,
18	6	Profit and Loss Diagram,
19	7	Profit and Loss Diagram,
20	8	Profit and Loss Diagram.

Sheet 1.

Sheet 1 is a Power Diagram for the Nipigon System covering the operation for the period between 1920 and 1931, inclusive. The years 1920, 1921 and 1922 are shown as under existing conditions. For the following years the loads are estimated. The basis of the estimate is given on page 7 of the above mentioned document.

In analyzing page 7, and Mr. Gaby's amplification of it, we have plotted the uppermost of the three curves, being that marked "Power Sold". The lowest of the curves, being that marked "Municipal Load", represents a determination of the amount of power which it is estimated will be disposed of for municipal

purposes. The centre curve, marked "Power Generated", has been deduced from a consideration of the diversity factor, having regard to the power sold and to the power generated, year by year.

It should be noted in passing that the estimated loads for the period from the year 1923 to 1931 are based on communications in the files of the Hydro-Electric Power Commission, and the Hydro-Electric Power Commission's interpretation of the whole situation.

Sheet 2.

Sheet 2 has been made to show Annual Revenue derivable from three different bases of selling rates. The curve marked "A", being that shown in dots, indicates the revenue, year by year, on the assumption that the power for municipal purposes is sold by the Hydro-Electric Power Commission at $20.00 per horse power per annum for the years 1921, 1922, 1923 and 1924; at $19.00 for the years 1925, 1926 and 1927; and at $18.00 for the years 1928, 1929 and 1930; and that the power for pulp mill use is sold at the uniform rate of $18.00 per horse power per annum.

The curve marked "B", being that shown in short dashes, is drawn on the assumption that all power used for municipal purposes is sold for $20.00 per horse power per annum; and all power for pulp mill use at $18.00 per horse power per annum.

The curve marked "C", being that shown in long dashes, is a plot of the revenue as set out on page 11 of the above mentioned document, in which the actual revenue has been plotted for the year 1921; the rate of $25.00 per horse

power per annum for power for municipal purposes is used for 1922; $20.00 for power for municipal purposes for the years 1923, 1924, 1925, 1926 and 1927; $16.00 for the year 1928; and $15.00 for succeeding years; $18.00 per horse power per annum being the constant rate for power for pulp mill use. In connection with this curve it should be stated that the distribution of the power on page 11 of the above mentioned document varies from that given on Sheet 1, in reference to the amount of power to be sold for pulp mill use.

Sheet 3.

Sheet 3, like the five which follow it, is a Profit and Loss Diagram.

It differs from the succeeding sheets only in the different rates for the sale of power, the rental for water and the rate of interest. As a result of the basis for the sale of power, the water rental and the interest charges used in its computation, Sheet 3 may be said to represent the extreme upper limit of those conditions, namely $20.00 per horse power per annum for power for municipal purposes for the years 1922, 1923 and 1924; $19.00 for the years 1925, 1926 and 1927; and $18.00 for the years 1928, 1929 and 1930; and $18.00 per horse power per annum for power for pulp mill use, throughout. Water rental to be paid by the Hydro-Electric Power Commission is considered on the basis of $1.00 per horse power per annum for power sold up to 70,000 horse power; interest has been taken on the capital expenditure at 6.2% per annum for the years 1921, 1922 and 1923; at 5.5% per annum for the year 1924; and at 5% per annum thereafter. Interest on the deficit has been computed at 5.5% per annum for the years 1922, 1923 and 1924, and at 5% per annum thereafter.

Throughout the computations interest has been compounded annually.

The uppermost curve shows the Total Operating Expense, year by year. The next succeeding curve shows the Total Revenue, year by year, while the curve below the datum line indicates the Accumulated Deficit, year by year.

In calculating the curve of total operating expense, page 40 of the above mentioned document has been used as a basis in regard to operation, maintenance, administration, water rental, interest, sinking fund, contingencies and depreciation. In all cases the figures of the Hydro-Electric Power Commission have been accepted unless we believed there were good reasons for modifying them in which case the reason is given. Referring to page 40, the figures of operation have been taken as therein stated, understanding that they are based on the operation records of the Hydro-Electric Power Commission. Maintenance has also been taken as given on page 40, because when combined with the items under the head of depreciation, on the same page, the results appear reasonable. The items under the head of administration, on the same page, are taken as there given, understanding that they are based on the records of the Hydro-Electric Power Commission. The annual charges for water rental, as given on page 40, have been modified in all cases, the basis for Sheet 3 being that of $1.00 per horse power per annum for all power sold up to 70,000 horse power. The items of interest, on page 40, have been modified in the manner explained for the Profit and Loss Diagrams, sheet by sheet. The items of the sinking fund, as given on page 40, have been accepted for use in the computations, being considered sufficiently accurate.

We have considered the capital expenditure at the end of the fiscal year,

October 31st, to be as follows:-

1921	$ 6,387,913.22,
1922	$ 6,562,207.77,
1923	$ 6,562,207.77,
1924	$ 9,150,000.00,
1925	$10,056,000.00,
1926	$11,718,000.00,
1927	$12,870,000.00,
1928	$12,870,000.00,
1929	$13,000,000.00,
1930	$13,000,000.00.

The figures for capital expenditure for the year 1924 and for subsequent years, have been used as given by the Hydro-Electric Power Commission on page 9 of the above mentioned document, as they appear to be sufficiently large.

The item of interest thereon has been taken at 6.2% per annum for the years 1921, 1922 and 1923, following at the same rate on the 1923 capital expenditure to the end of 1930. Interest for the year 1924 has been taken at 5.5% per annum on the capital expenditure for that year, and at the same rate on the amount of the increase as between 1923 and 1924, continuing to the end of 1930. The interest on all capital expenditure added for the year 1925 and thereafter has been computed at 5% per annum. On the deficit, interest has been computed at the rate of 5.5% per annum for the years 1922, 1923 and 1924, and at 5% per annum thereafter.

The conditions assumed for Sheet 3 are the most unfavorable on which we have

based our calculations, from the viewpoint of the Nipigon System. The accumulated deficit increases year after year, and will not be overcome within the period of time under consideration.

Sheet 4.

Sheet 4 is in the same form as Sheet 3 and is comparable therewith, excepting that the rate for power for municipal purposes has been chosen at $20.00 per horse power per annum; the rate for power for pulp mill use has been taken at $18.00 per horse power per annum; water rental has been taken at $1.00 per horse power per annum for power sold up to 70,000 horse power; while interest has been taken exactly as for Sheet 3.

The conditions under which this table has been calculated are more favorable to the System than the conditions assumed for Sheet 3, and while the former shows that the accumulated deficit will continue to increase, Sheet 4 shows that the accumulated deficit will disappear about the year 1939 under its assumed conditions.

Sheet 5.

Sheet 5 is calculated on the same principle as Sheet 4. The same rates for the sale of power have been assumed, and the same interest rates have been used, but the water rental is assumed to be $0.50 per horse power per annum for power generated up to 50,000 horse power.

Sheet 5 shows that the results are more favorable than in either of the previous sheets, and that the accumulated deficit will disappear in the year 1933

under its assumed conditions.

Sheet 6.

Sheet 6 is calculated on the same principle as Sheet 5, the only difference being that 5% per annum has been used as the rate of interest throughout.

Sheet 6 shows the accumulated deficit disappearing in the year 1928 under its assumed conditions.

Sheet 7.

Sheet 7 has been calculated on the same principle as Sheet 6, with the differences that the rate of $0.50 per horse power per annum for water rental has been taken on power sold with a limit of 70,000 horse power; and that the rate for power for municipal purposes diminishes from $25.00 down to $15.00, as given on page 11 of the above mentioned document.

Sheet 7 shows the accumulated deficit disappearing in the year 1926 under its assumed conditions.

Sheet 8.

Sheet 8 has been calculated on the same principle as Sheet 7 with the differences that power for municipal purposes has been taken at a constant selling rate of $20.00 per horse power per annum; power for pulp mill use at a constant rate of $18.00 per horse power per annum; that there are no charges for water rental; and that all interest has been computed at 5% per annum.

Sheet 8 shows the accumulated deficit disappearing in the year 1927 under its assumed conditions.

This curve is calculated for the most favorable set of conditions which we have considered, with the single exception of the rate of $25.00 per horse power per annum at the commencement as given by the Hydro-Electric Power Commission on page 11 of the above mentioned document.

Table of Accumulated Deficits.

As a résumé of the principal features of the items of accumulated deficit in the diagrams, and for the sake of easy reference, the following figures are taken from the calculations on which the diagrams are based:-

Conditions as in Sheet	Maximum Accumulated Deficit Amount	Year	Accumulated Deficit Ends
3	$929,404	1928.	(accumulated deficit increases)
4	843,714	1927	1939 (about)
5	706,297	1926	1933
6	263,593	1924	1928
7	97,063	1924	1926
8	232,693	1924	1927

Conclusion.

Speaking briefly, Sheets 3, 4, 5, 6, 7 and 8 are Profit and Loss Statements, under certain assumed conditions in stated combinations. The varying conditions are a municipal selling rate diminishing from $25.00 per horse power per annum to $15.00 per horse power per annum; a rate of interest varying between 6.2% per annum and 5% per annum; and a water rental varying between $1.00 per horse power per annum for power sold up to 70,000 horse power, and no charge for water rental.

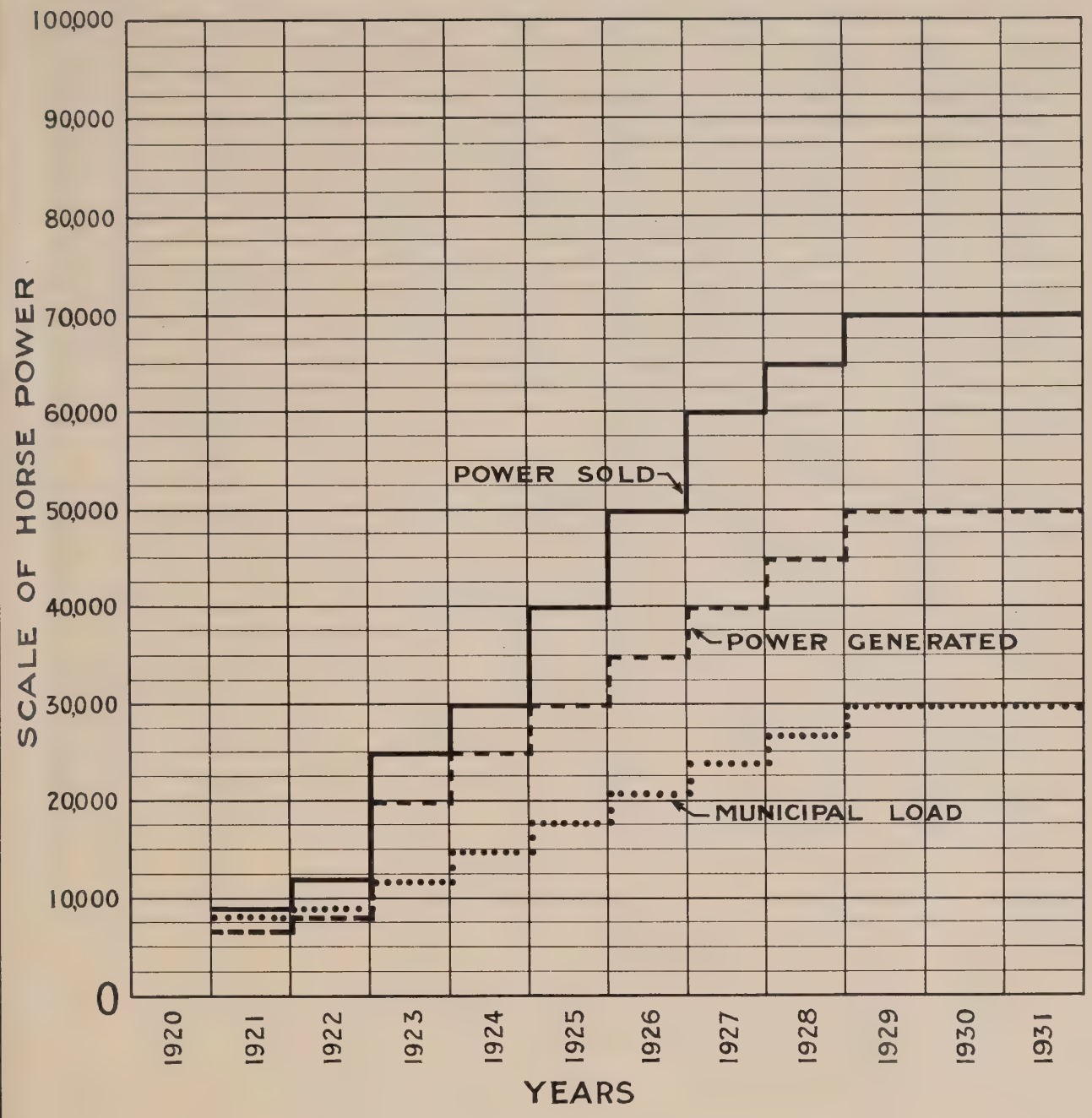
In those cases where the figures of the Hydro-Electric Power Commission in the volume containing the estimates thereof have been accepted as accurate for the purpose in hand, little or no effect would appear in the results which we have obtained by adjustments which, conceivably, might be made in the original figures. Therefore, as no useful purpose would be served, no attempt has been made to adjust the figures, and I believe the results obtained are sufficiently accurate for all practical purposes.

Walter J. Francis

Toronto, September 18th, 1922. Consulting Engineer.

Dear Sir,

POWER DIAGRAM



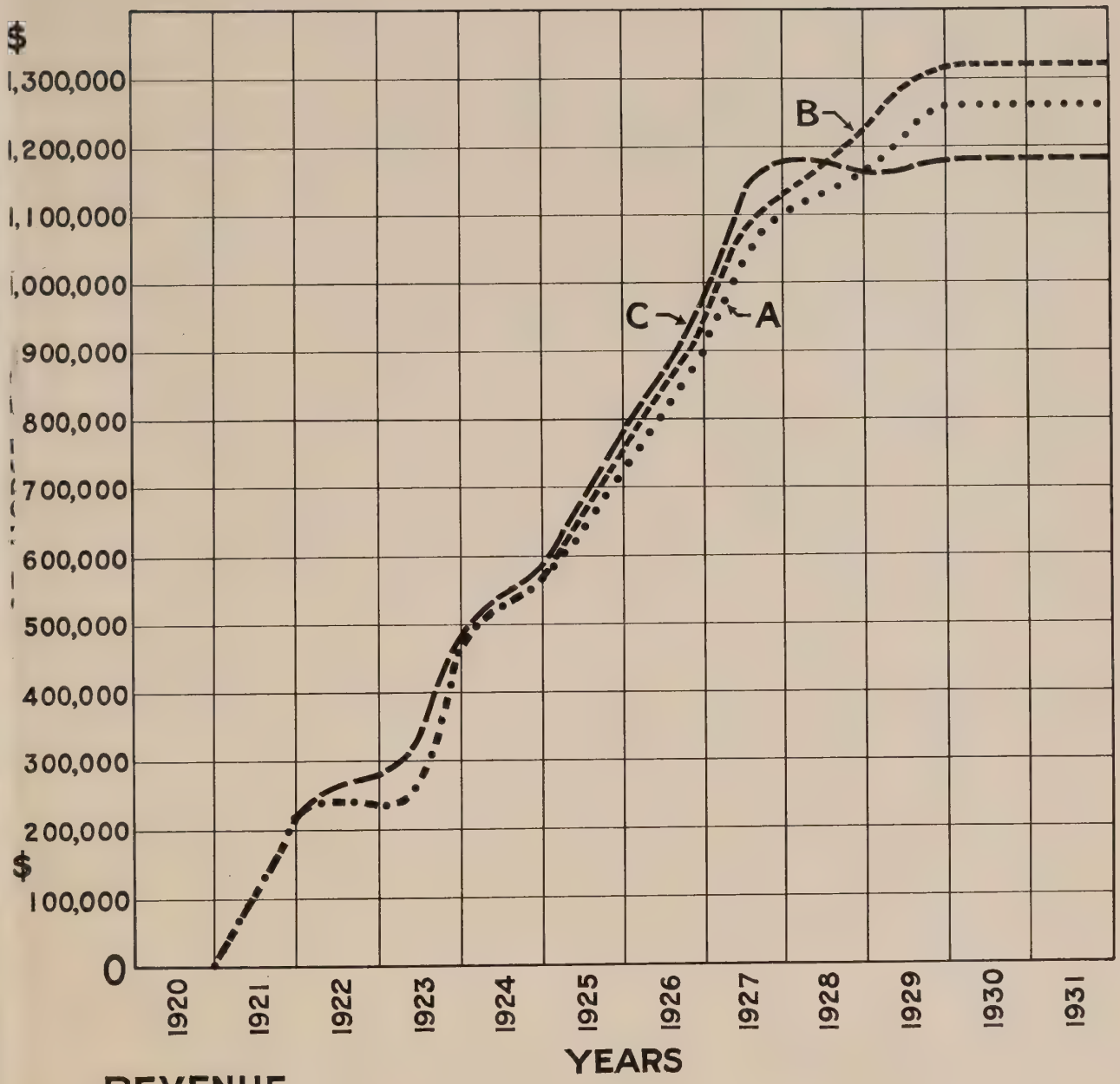
SHEET 1

HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY - CHAIRMAN

NIPIGON SYSTEM
— STUDY OF —
ENGINEERING ECONOMICS
(EIGHT SHEETS)

Toronto, Sep. 14th., 1922, Made by SCH, Checked by WJF.
WALTER J. FRANCIS, C. E.
CONSULTING ENGINEER

ANNUAL REVENUE DIAGRAM



REVENUE

Selling Rate –

Curve A, Municipal Power $20 per H-P. per Annum diminishing to $18
Pulp Mill Power $18 per H-P

Curve B, Municipal Power $20 per H-P.
Pulp Mill Power $18 per H-P.

Curve C, Municipal Power $25 per H-P. per Annum diminishing to $18
Pulp Mill Power $18 per H-P.

SHEET 2

HYDRO-ELECTRIC INQUIRY COMMISSION
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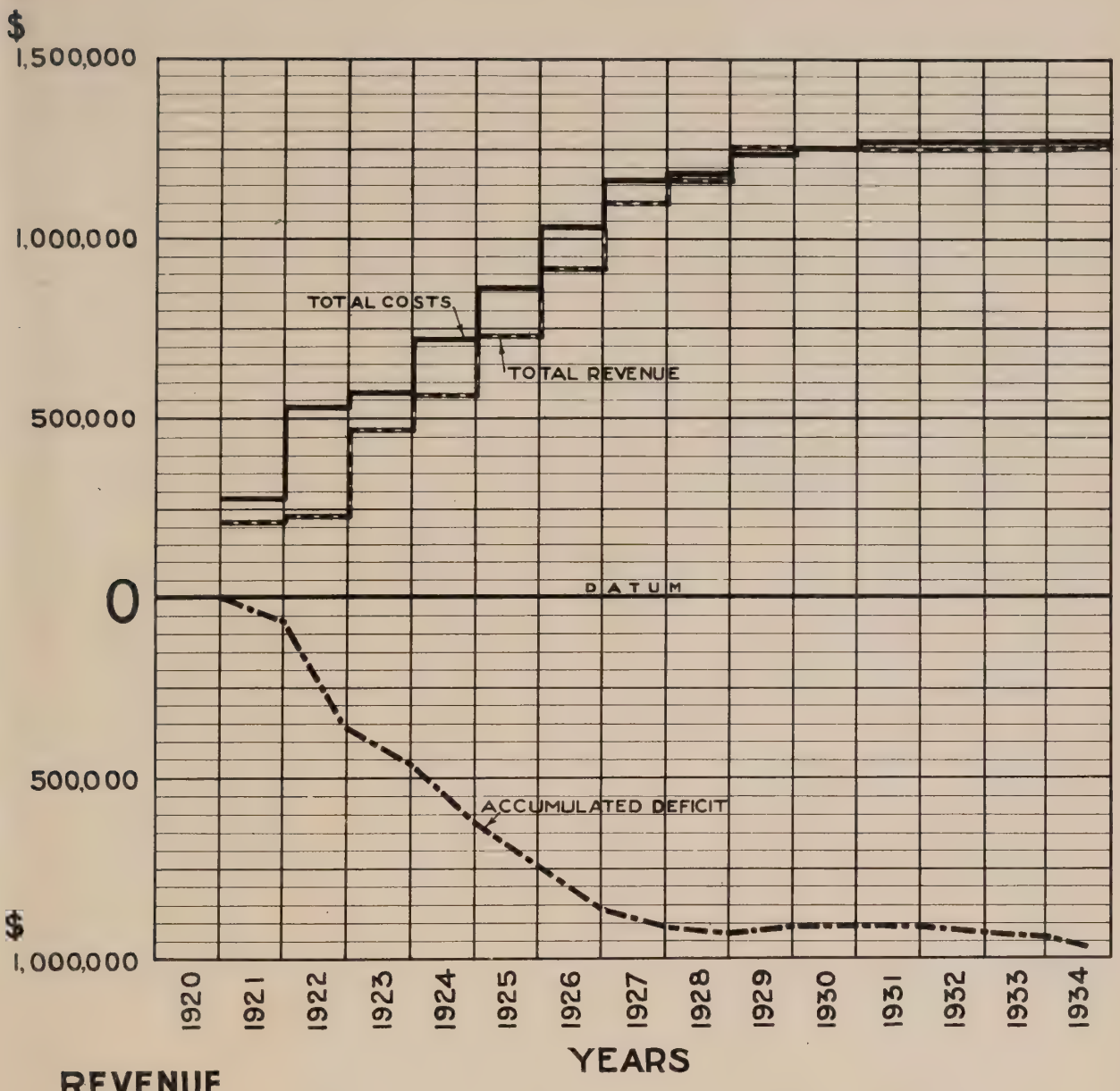
PROFIT AND LOSS DIAGRAM



REVENUE

Selling Rate - Municipal Power $20 diminishing to $18
Pulp Mill Power $18

EXPENSE

Water Rental - $1 per H-P per Annum for Power Sold. Limit 70,000 H-P

Interest - On Capital - 6·2% per Annum diminishing to 5%

On Deficit 5·5% per Annum diminishing to 5%

SHEET 3

HYDRO-ELECTRIC INQUIRY COMMISSION
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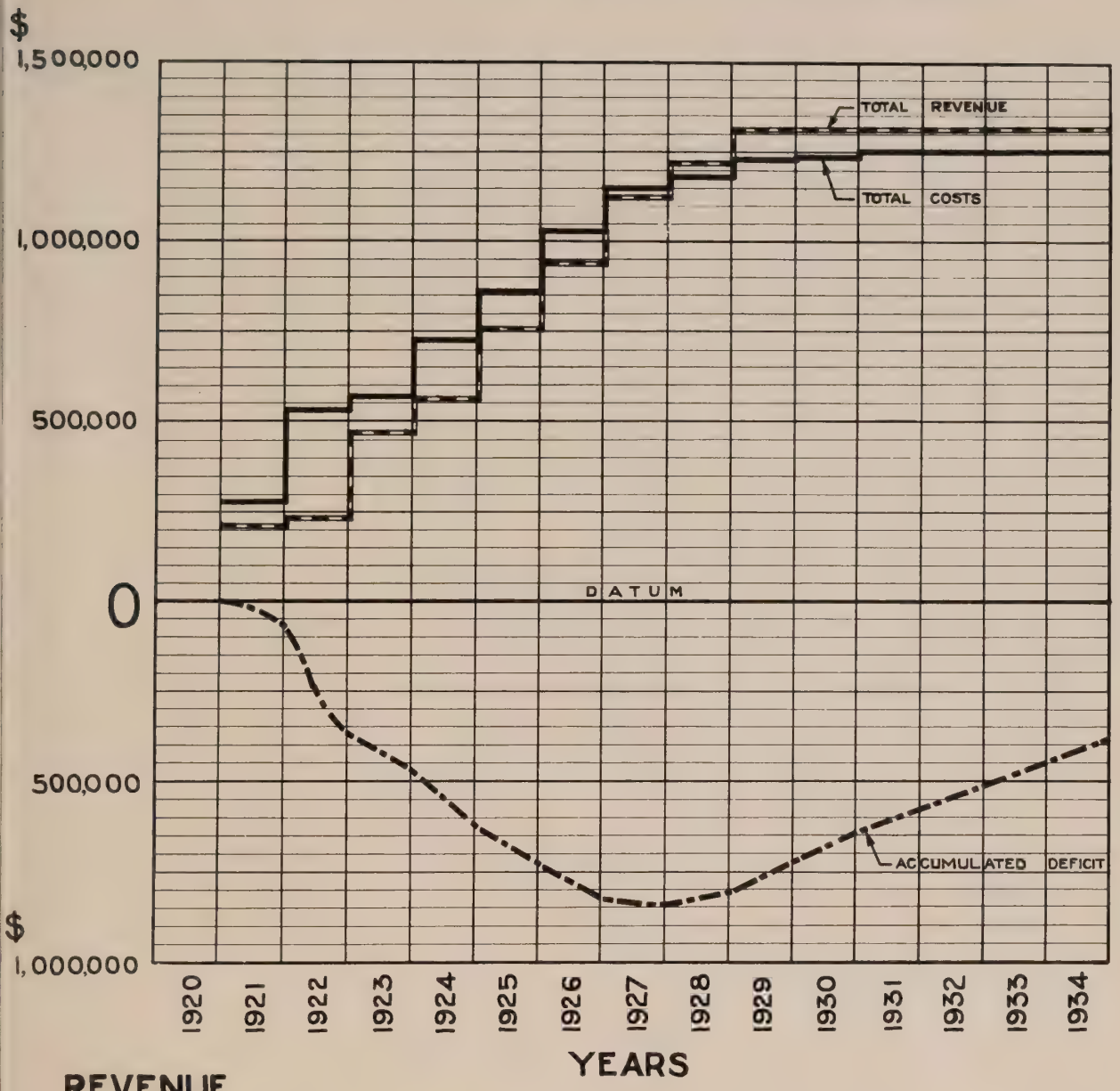
PROFIT AND LOSS DIAGRAM



REVENUE

Selling Rate - Municipal Power - $20
Pulp Mill Power - $18

EXPENSE

Water Rental - $1 per H.P. per Annum for Power **Sold**. Limit 70,000 H.P.

Interest - On Capital - 6·2% per Annum diminishing to 5%.

On Deficit 5·5% per Annum diminishing to 5%.

SHEET 4

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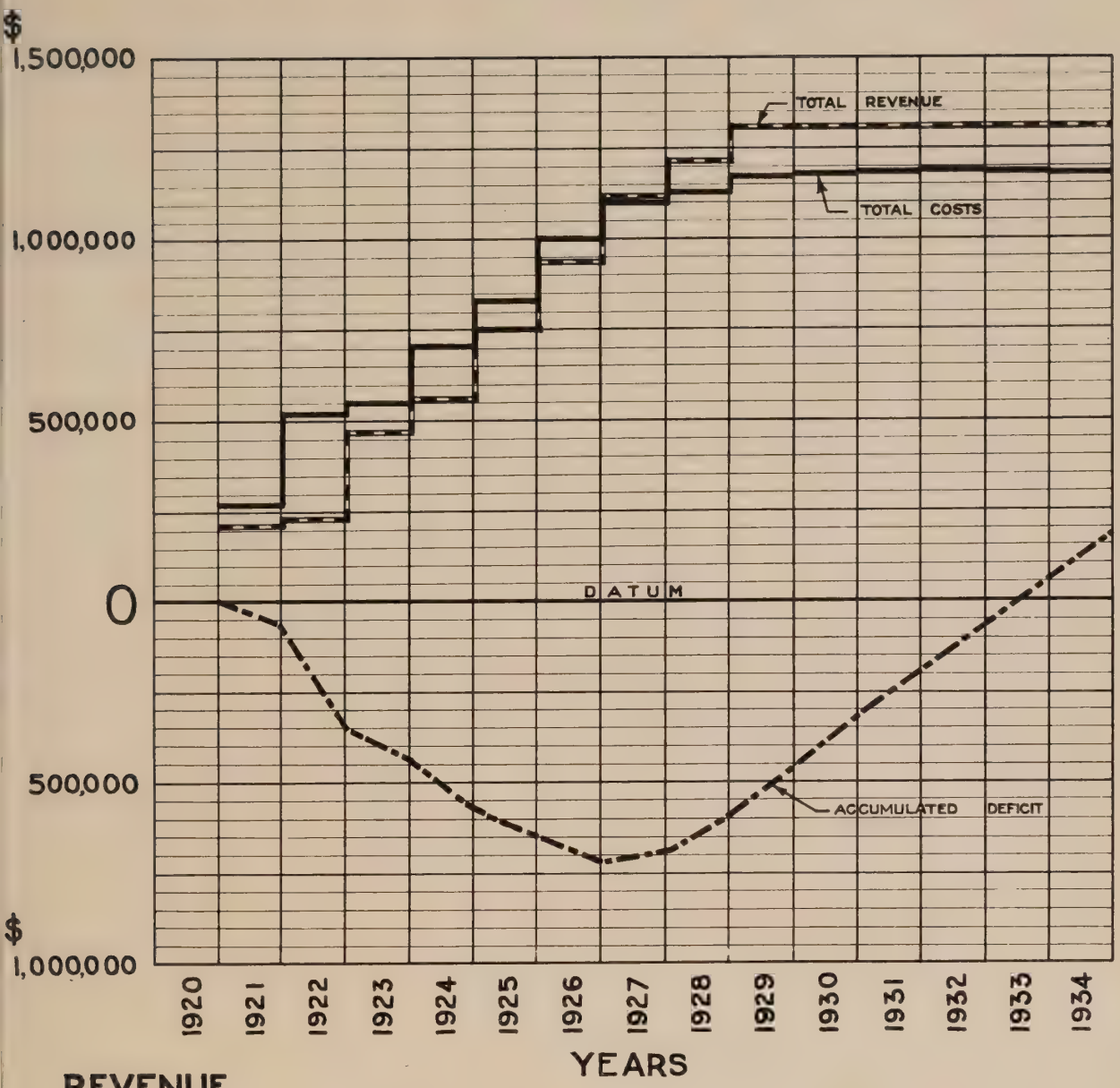
PROFIT AND LOSS DIAGRAM



REVENUE

Selling Rate - Municipal Power $20
Pulp Mill Power $18

EXPENSE

Water Rental - $0.5 per H.P. per Annum for Power Generated. Limit 50,000 H.P.

Interest - On Capital - 6·2% per Annum diminishing to 5%

On Deficit 5·5% per Annum diminishing to 5%

SHEET 5

HYDRO-ELECTRIC INQUIRY COMMISSION
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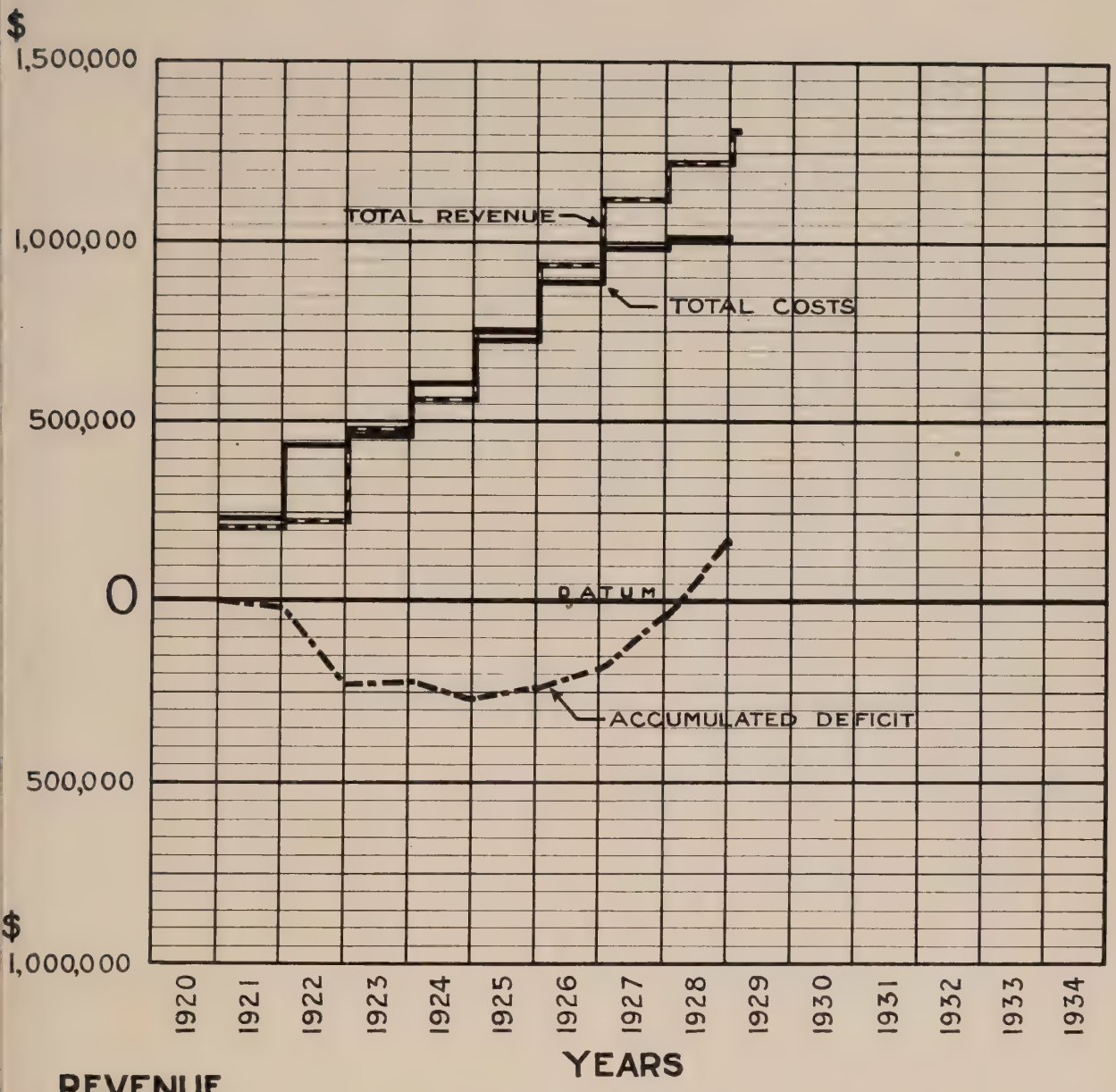
PROFIT AND LOSS DIAGRAM



REVENUE

Selling Rate - Municipal Power - $20
Pulp Mill Power - $18

EXPENSE

Water Rental - $0·5 per H.P. per Annum for Power Generated. Limit 50,000 H.P.

Interest - On Capital - 5% per Annum.
On Deficit - 5% per Annum.

SHEET 6

HYDRO-ELECTRIC INQUIRY COMMISSION
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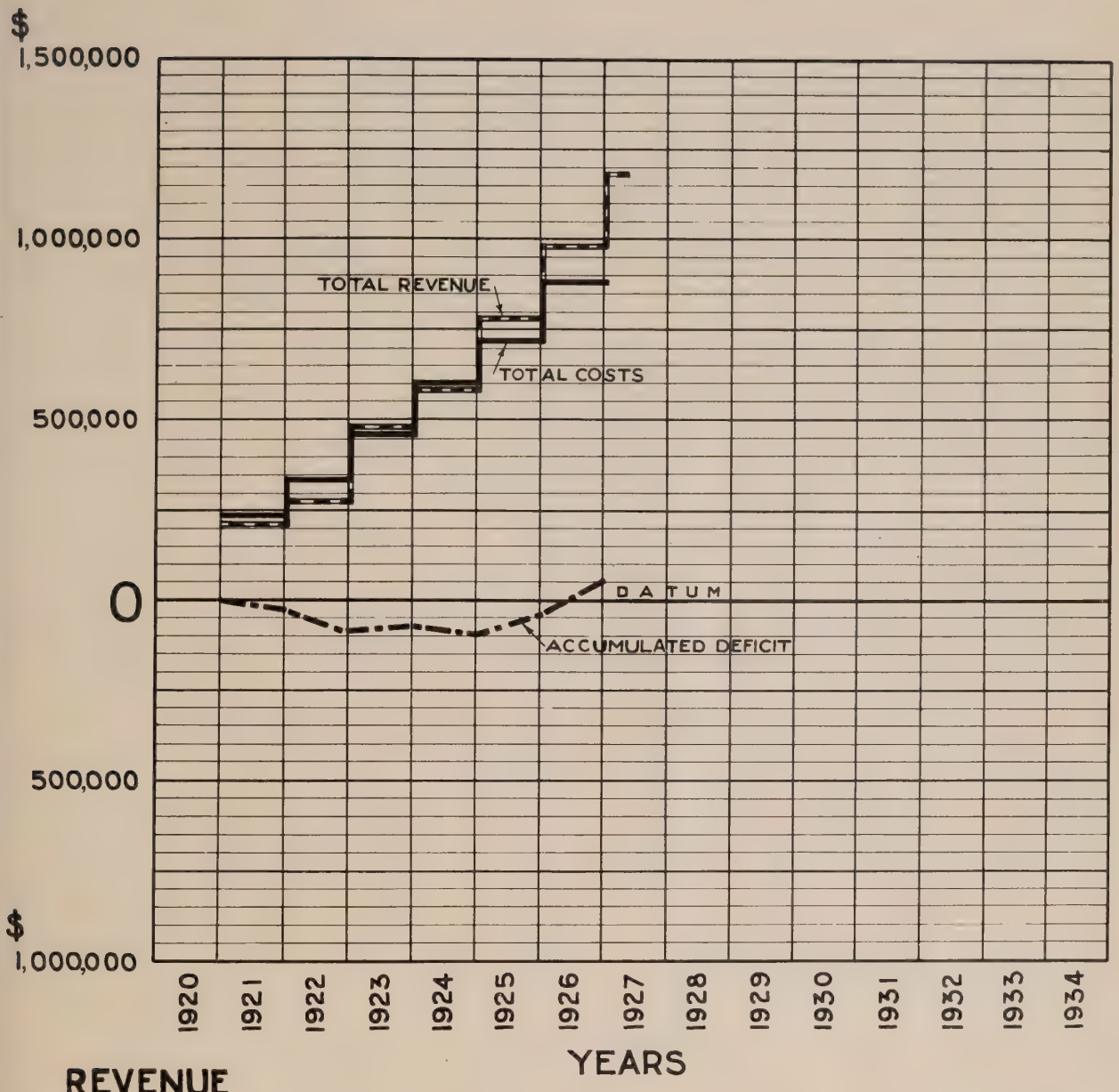
PROFIT AND LOSS DIAGRAM



REVENUE

Selling Rate - Municipal Power - $25 diminishing to $15
Pulp Mill Power - $18

EXPENSE

Water Rental - $0·5 per H.P. per Annum for Power Sold. Limit 70,000 H.P.

Interest - On Capital - 5% per Annum.
On Deficit - 5% per Annum.

SHEET 7

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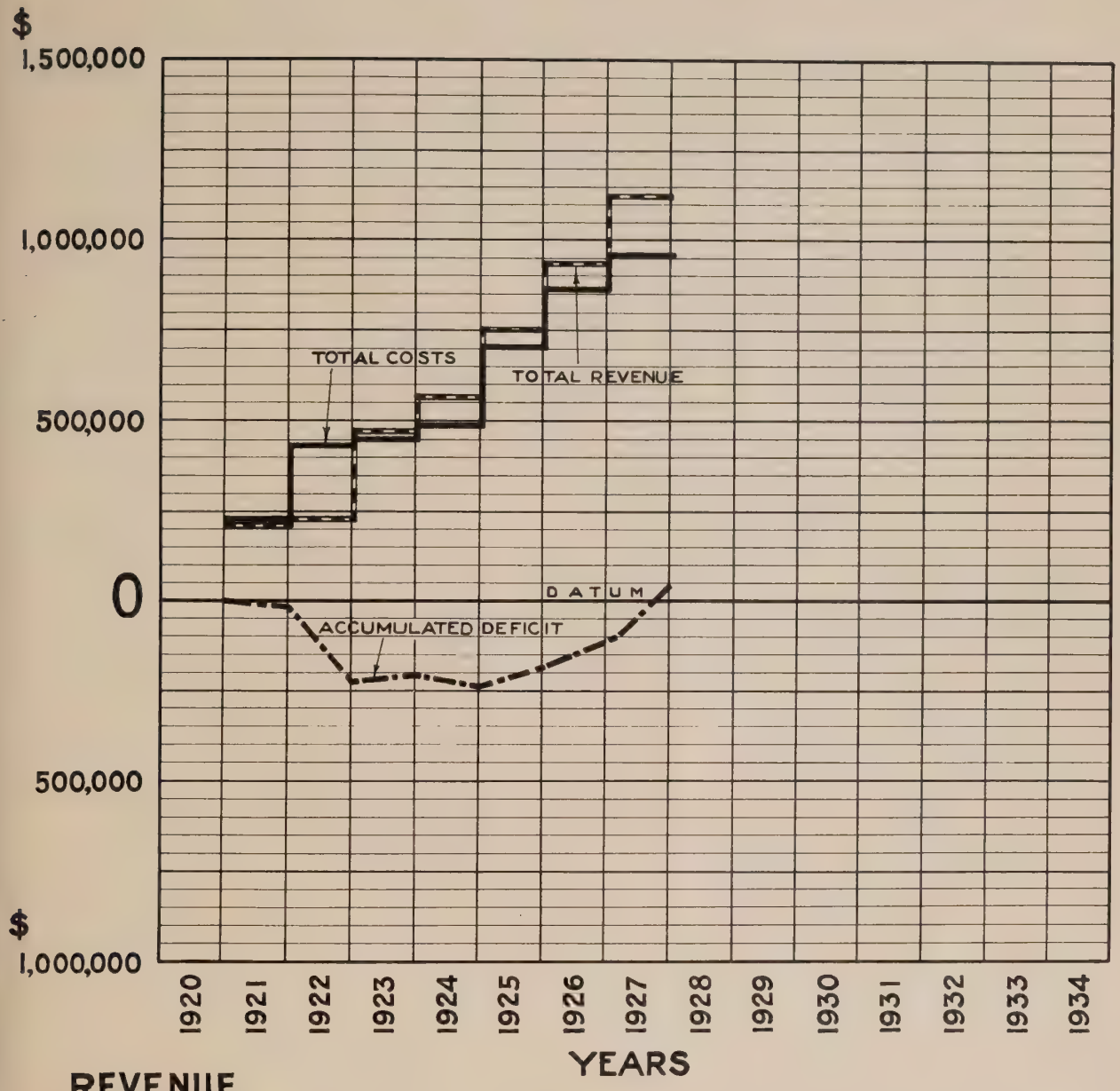
PROFIT AND LOSS DIAGRAM



REVENUE

Selling Rate – Municipal Power – $20
Pulp Mill Power – $18

EXPENSE

Water Rental – Gratis.
Interest – On Capital – 5% per Annum.
On Deficit – 5% per Annum.

SHEET 8

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